The evolution of PHENIX to sPHENIX and ePHENIX

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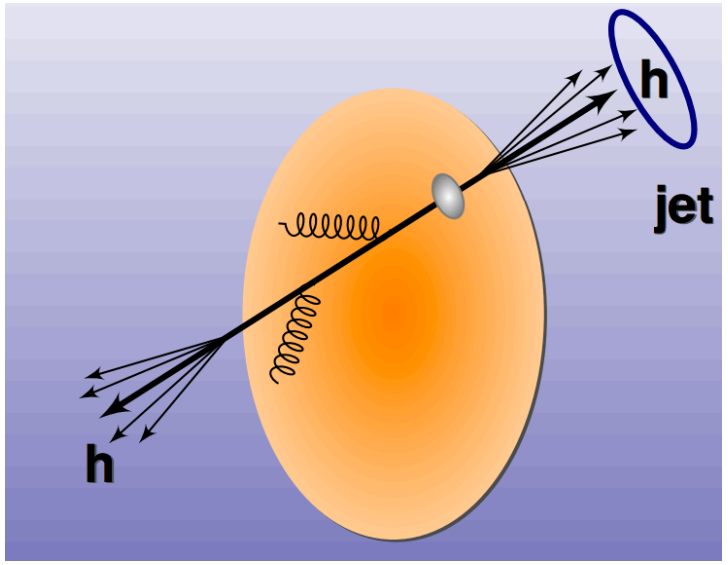
The sPHENIX Experiment

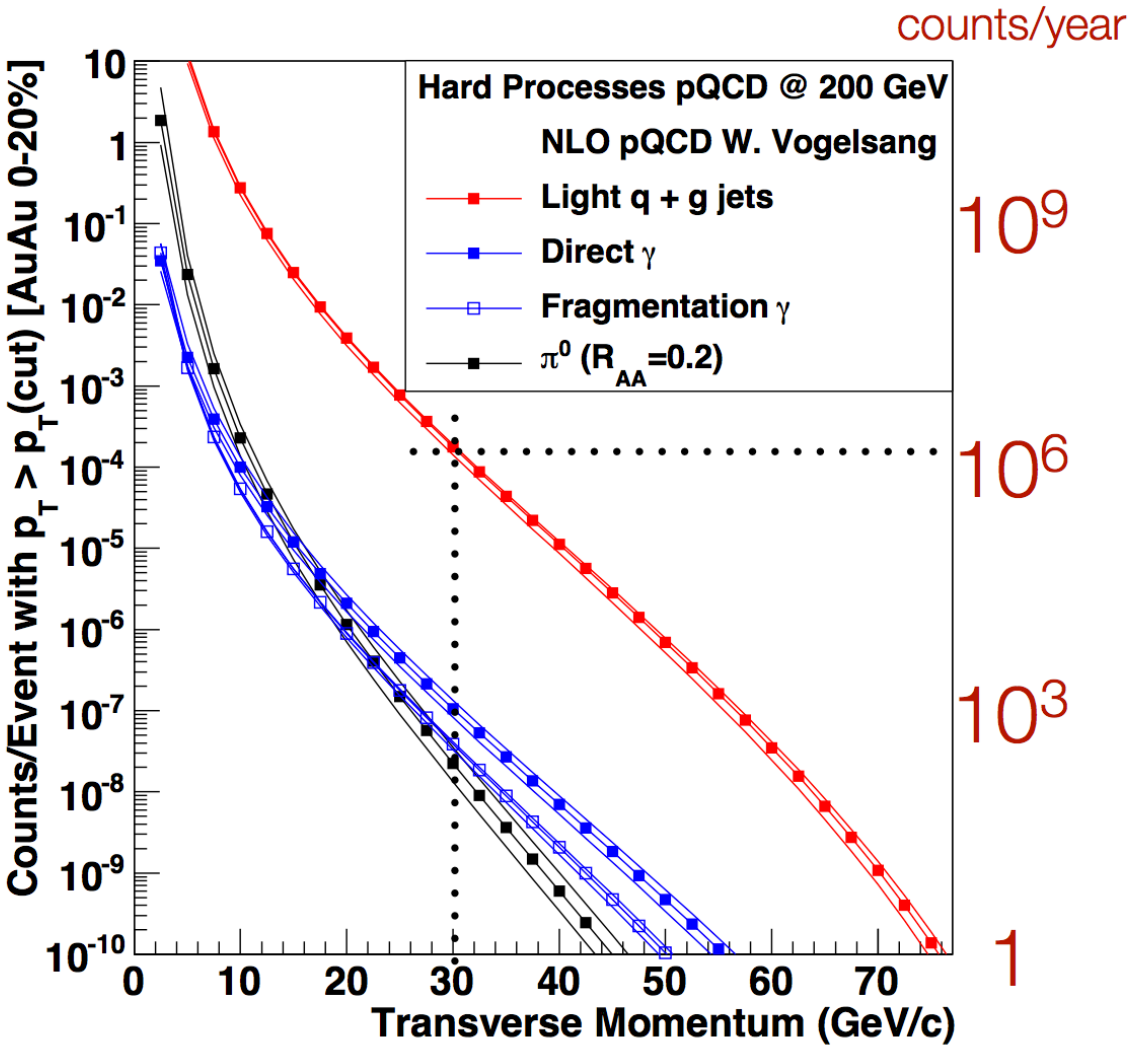
- Major upgrade to the PHENIX Experiment at RHIC
- Primary purpose is to measure jets in heavy ion collisions
  - Measure jet energy using calorimetry
  - Good solid angle coverage ($|\eta| < 1$, $\Delta\phi = 2\pi$)
- Provide a basis for a future detector at eRHIC
  - Study nucleon structure and QCD in nuclei over a broad range of x and Q^2 using deep inelastic polarized ep and eA collisions

Why a jet experiment?

- The next steps in studying the quark gluon plasma are detailed studies of its properties
- Jets are the strongly interacting probe needed for these studies
- The QGP produced at RHIC is near the transition temperature and so allows us to study how the system evolves with temperature



Jet rates in Au+Au at 200 GeV



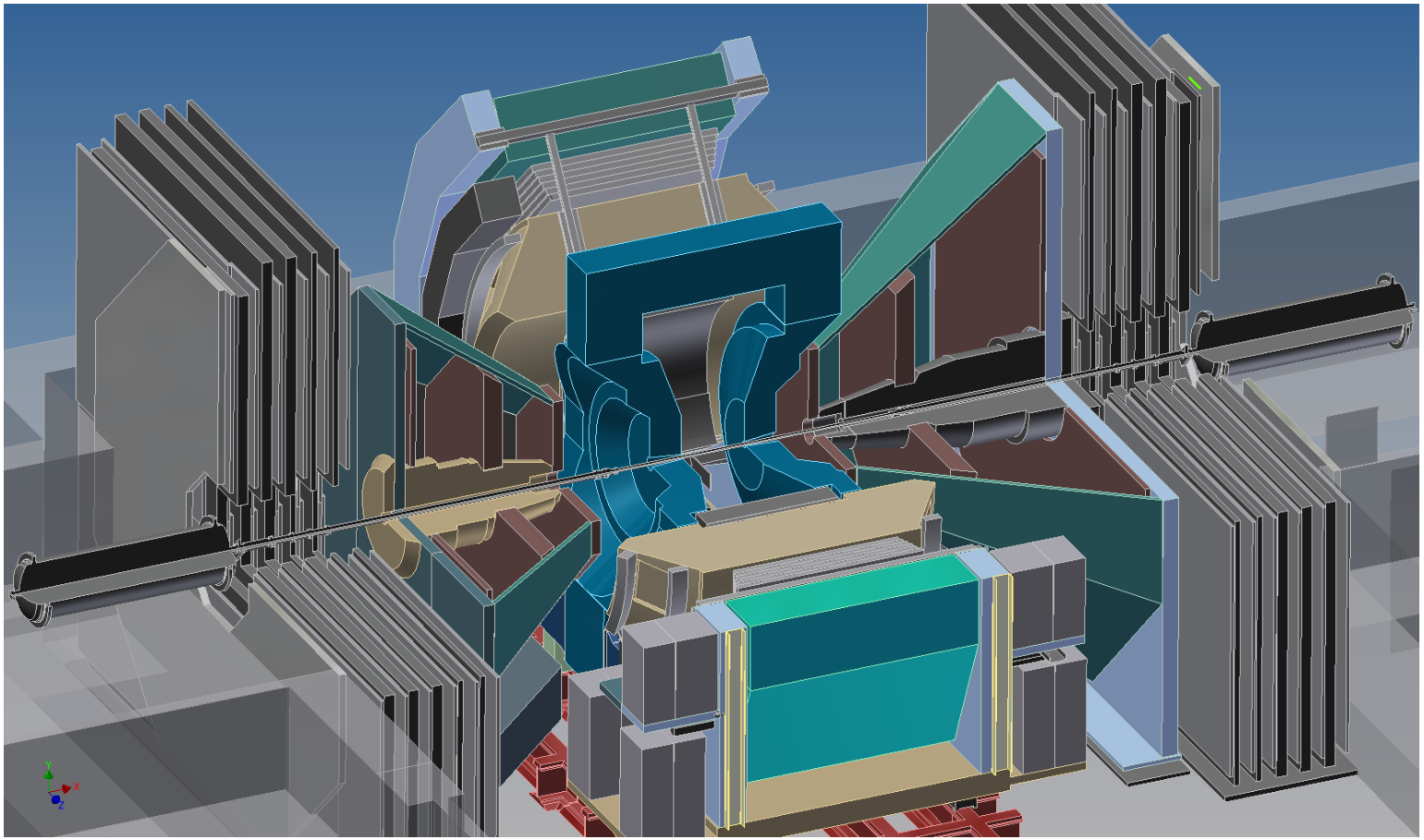
There are *lots* of jets!

Only stochastic cooling of Au beams assumed

Greater rate and p_T reach than singles

1 RHIC year = 50 billion min. bias Au+Au events = 10 billion central

PHENIX



The next generation RHIC detector

- Excellent electromagnetic and hadronic calorimetry
- Superconducting magnet for a high resolution charged particle tracking spectrometer
- Good electron identification
- Large and hermetic acceptance
- High speed and high rate capability

Proposal status

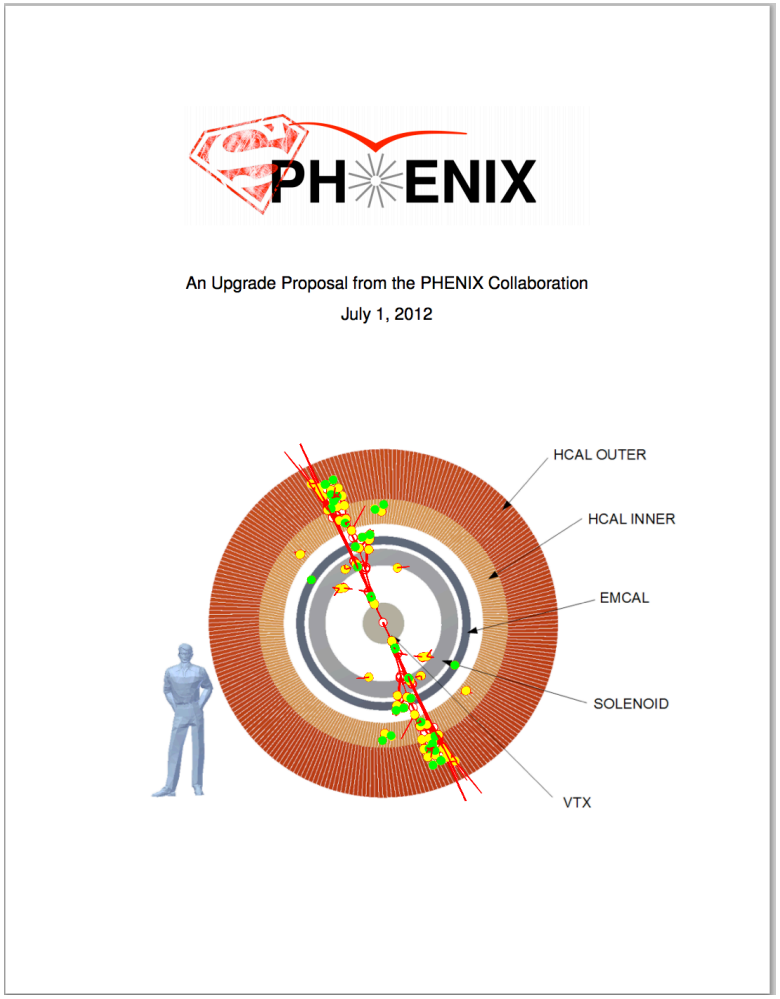
The sPHENIX proposal timeline so far:

- October 1, 2010 Decadal plan
- July 1, 2012 Proposal submitted to BNL
- October 5-6, 2012 Laboratory review
- February 1, 2013 Revised proposal released
- March 29, 2013 Submitted to ONP
- May 7, 2013 ALD requests LOI for EIC due September 30
- May 30, 2013 ALD requests draft LOI August 31
- October 1, 2013 BNL submits PHENIX and STAR LOI's and a transition plan to eRHIC to DOE

Proposed to BNL

Submitted to BNL a year and a half ago

- Superconducting solenoid
  - 2 T
  - 70 cm inner radius
  - $|\eta| < 1.1$
- Tungsten-scintillator EMCAL outside coil
- Steel-scintillator HCAL
- Silicon tracker with additional planes at about 60 cm
- Preshower detector



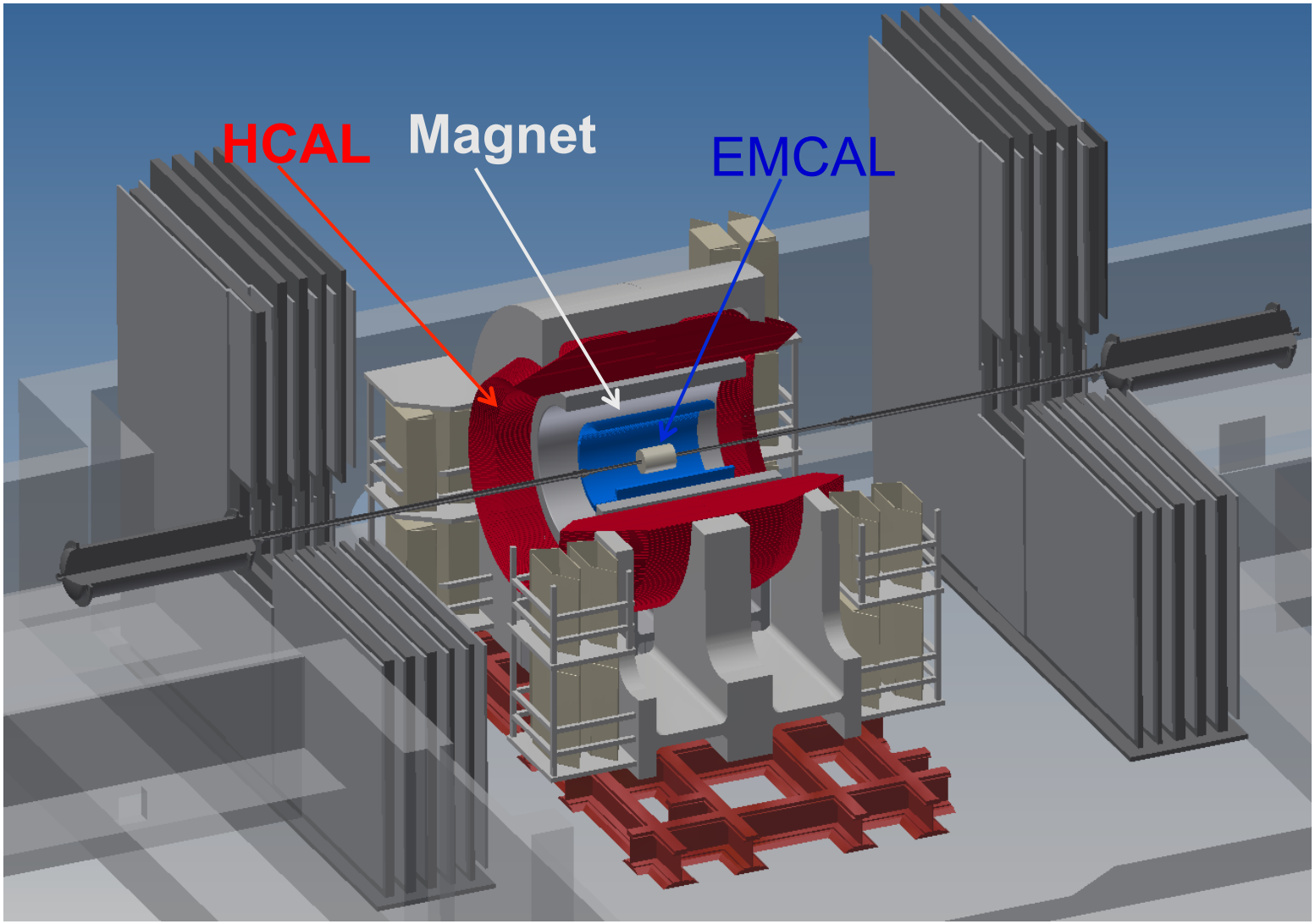
BNL review in October 2012

Very useful review at BNL by John Harris, Mike Harrison, Miklos Gyulassy, Jimmy Proudfoot, Raju Venugopalan, Bolek Wyslouch, Xin-Nian Wang

- "The Committee therefore strongly endorses the science case for this program."
- Several recommendations to strengthen proposal
  - move discussion of non-DOE funded additional tracking and EMCal pre-shower from appendix to main body of MIE to underscore how they broaden the physics case
  - further GEANT studies
  - increase contingency on solenoid to reflect current-day challenges in procuring superconducting magnets

Where are we now?

- Proposal status
  - We have met with DOE ONP to establish a path forward
  - The new Associate Director (Berndt Mueller) and his Deputy (David Lissauer) have been very supportive
  - It has been made clear that sPHENIX must not be a dead end, but can be an important part of future experiments at an eRHIC (LOI)
- Physics status
  - Studies of jets near T_c is recognized as an important suite of measurements and theoretical activity is ramping up
- Detector status
  - Prototype detectors under construction for beam test
  - A very fortunate development with the magnet


HCAL
Magnet
EMCAL

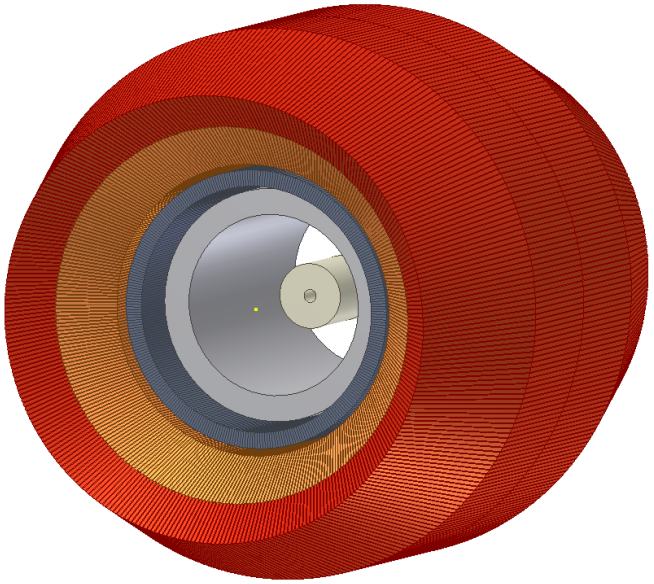
Solenoid magnet

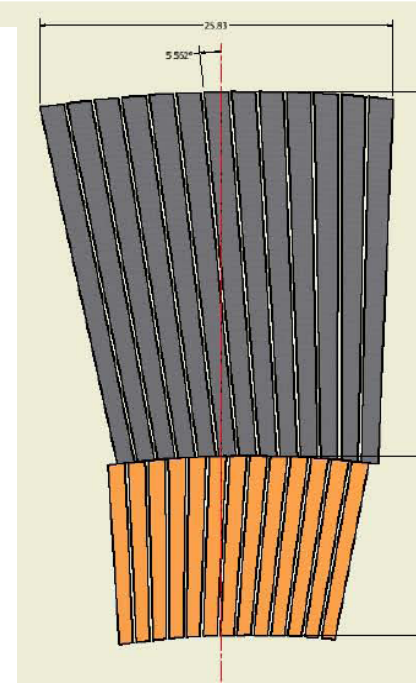
- Former BaBar magnet has been transferred to BNL for sPHENIX along with much supporting equipment with cancellation of SuperB
  - Central field: 1.5 T
  - Inner radius: 1.4 m
  - Covers $|\eta| < 1$
- Currently working on making sure it comes to BNL Magnet Division in good condition

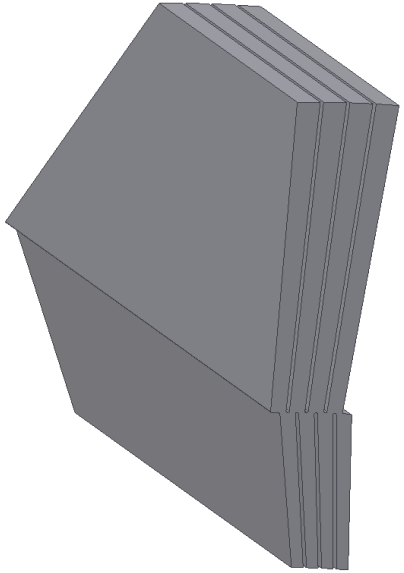
Calorimeter Requirements

- Large solid angle coverage (± 1.1 in η, 2π in ϕ)
- Moderate energy resolution
  - EMCAL ~ 15%/$\sqrt{E}$
  - HCAL ~ 75 %/$\sqrt{E}$ (single particle), ~100 %/$\sqrt{E}$ (jet)
- Compact (for EMCAL $\Rightarrow$ small R_M, short X_0)
  - Physically small (dense) – occupies minimal space
  - High segmentation for heavy ion collisions
- Hermetic
- Projective (approximately)
- Readout works in a magnetic field
- Low cost

sPHENIX Hadron Calorimeter





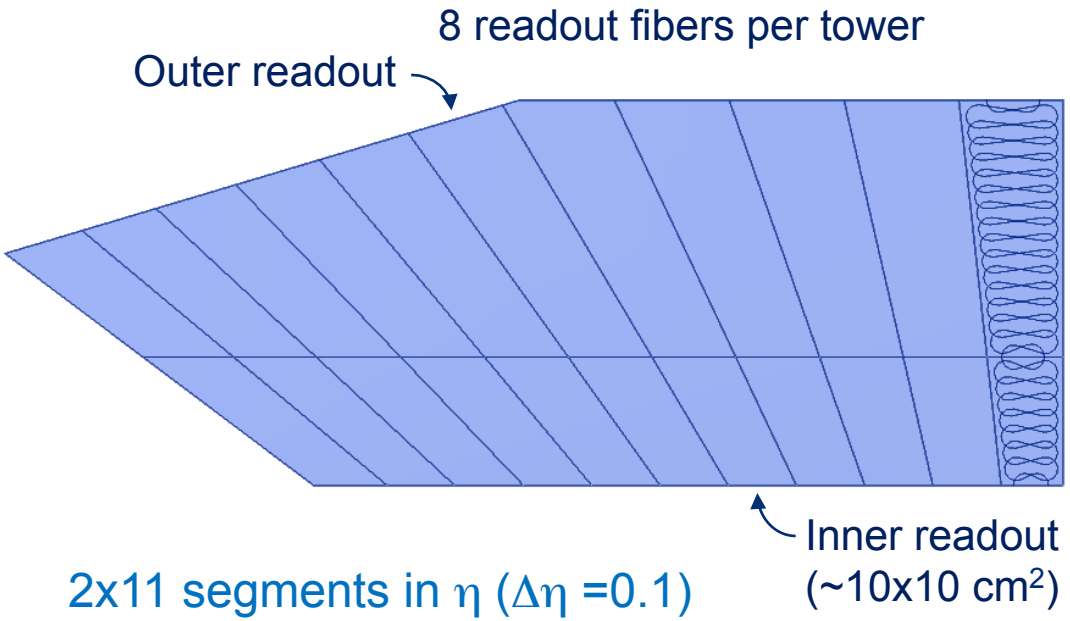


4 inner and 4 outer plates joined together to form one section

- Steel plates with scintillating tiles parallel to beam direction
- Steel serves as flux return
- Steel plates are tapered
  ⇒ Sampling fraction changes with depth
- Divided into two longitudinal sections
  Measure longitudinal center of gravity to correct for longitudinal fluctuations
- Plates tilted in opposite directions to avoid channeling

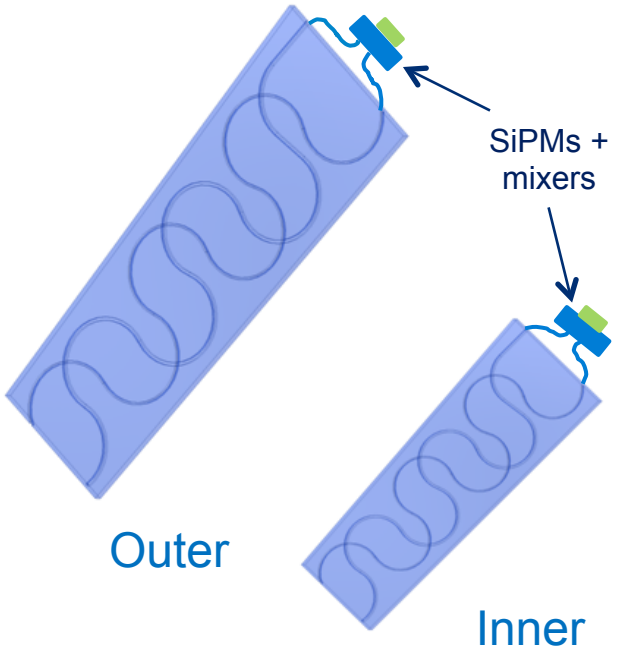
HCAL Readout

Scintillating tiles with WLS fibers embedded in grooves
Fibers read out with SiPMs

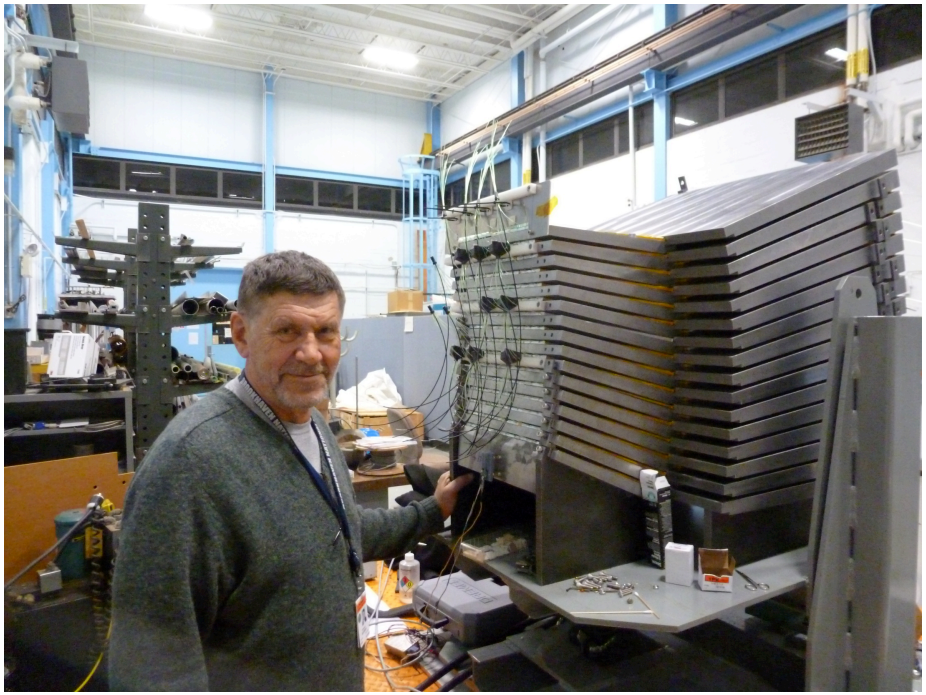


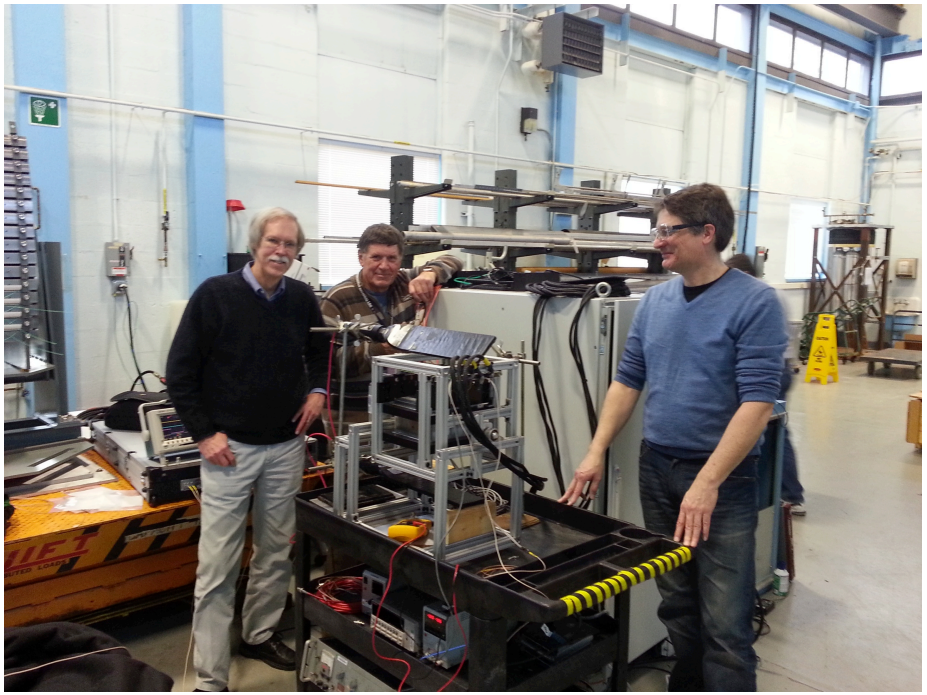
2x11 segments in η ($\Delta\eta$ =0.1)
64 segments in ϕ ($\Delta\phi$ =0.1)
1408 x 2(inner,outer) = 2816 towers

2x11 scintillator tile shapes



sPHENIX Calorimeter Prototypes





Headed to Fermilab Test Beam next week

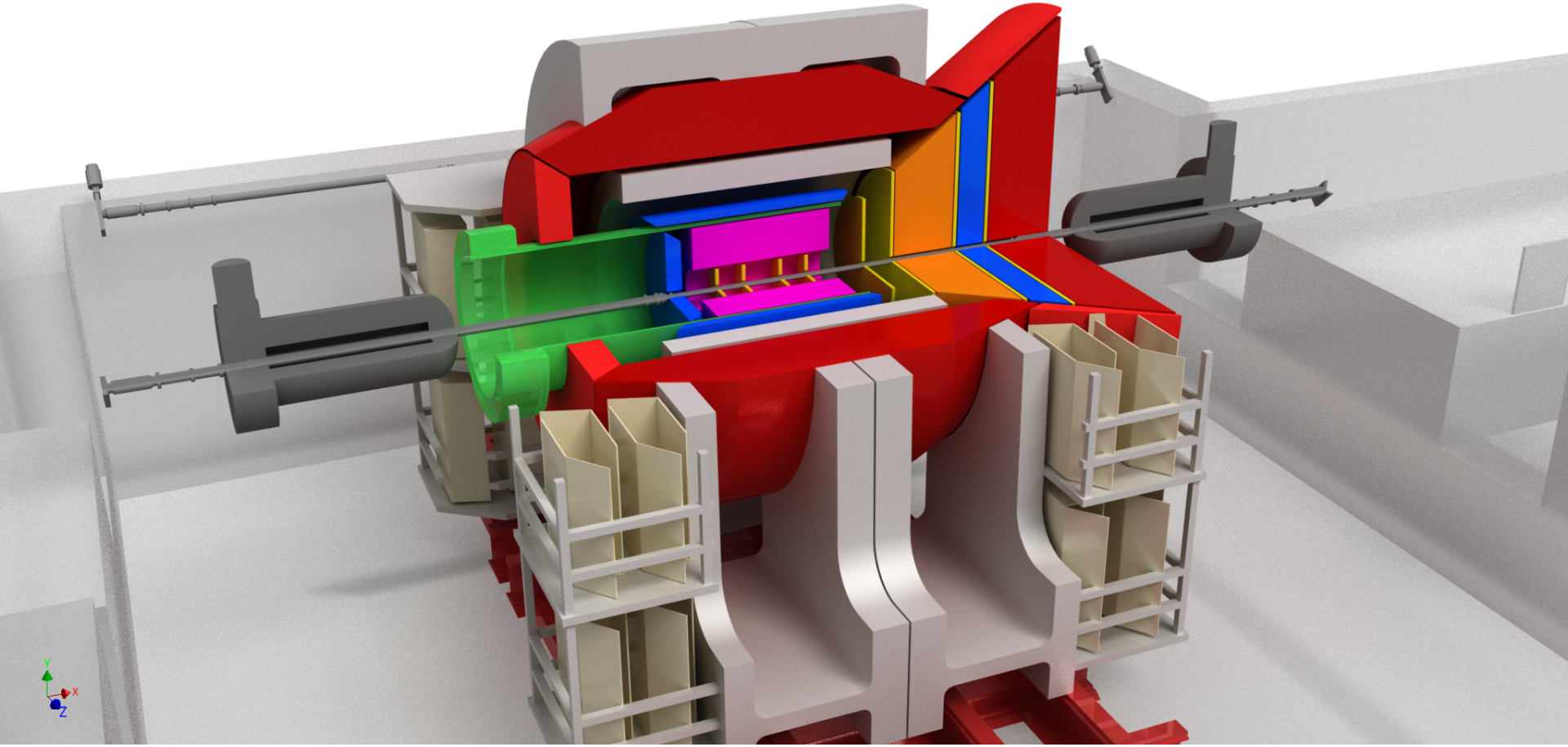
Evolution to a detector for an electron-ion collider

- We were asked to write a Letter of Intent for a DIS experiment at an electron-ion collider using the RHIC ring (eRHIC)
- eRHIC initial experiments would be with 5-10 GeV e- on 100-250 GeV polarized p

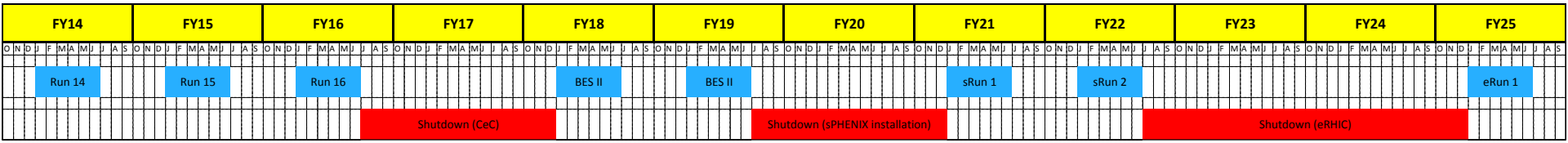
ePHENIX

- A Letter of Intent for an eRHIC detector based on sPHENIX is what we are considering today
- The design being considered is based upon the BaBar magnet as an upgrade beyond sPHENIX

ePHENIX



Timeline



- We want sPHENIX construction start in FY16
- sPHENIX jet physics FY21-22
- Add capability for ePHENIX for operation in FY25 and beyond

Summary

- PHENIX is planning a major detector upgrade to replace its existing Central Arm Spectrometer with a new calorimeter system consisting of an electromagnetic and hadronic calorimeter
- These new calorimeters will enable a detailed systematic study of jets produced in heavy ion collisions at RHIC to study the QGP near its transition temperature and is being designed from the beginning with eRHIC experiments in mind